NOTE ON THE GALVANOTROPIC RESPONSE OF THE EARTHWORM[1]

A. R. MOORE AND F. M. KELLOGG,

BIOLOGICAL LABORATORY OF BRYN MAWR COLLEGE, BRYN MAWR, PA.

Since Blasius and Schweizer[2] first found that many animals, both aquatic vertebrates and invertebrates, orient themselves characteristically to the electric current, the galvanotropic response has been studied carefully by a number of investigators in paramecia, motile algæ, medusa strips and tentacles, certain crustacea and salamanders. In general it may be stated that under normal conditions, paramecia, motile algæ, and pieces of medusa tend to move toward the kathode, while vertebrates and crustacea which are galvanosensitive, progress toward the anode and avoid the kathode either by turning away from it or by walking backward. Loeb[3] and his collaborators account for the coördinated movements of vertebrates and crustacea under the influence of the electric current by suggesting that they are due to changes in the tension of associated muscle groups, viz: flexors and extensors.

It seemed that the earthworm, *Lumbricus terrestris*, with its simple locomotor system of circular and longitudinal muscles offered favorable material for testing this idea. The following is an account of the response of this animal to the constant electric current, based on a large number of observations made on different individuals at different seasons of the year. It is true that Blasius and Schweizer noted the galvanotropic response of *Lumbricus* but unfortunately limited their description to the stimulating effects of the "make" shock and the final crawling of the animal to the kathode, consequently omitting mention of the significant intermediary stages due alone to the flow of the constant current.

In our own experiments, an animal to be tested was put into a

[1] Drawings by Mary Cline.

[2] Blasius and Schweizer, *Pflueger's Archiv*, Bd. 53, S. 493.

[3] Loeb, J., *Pflueger's Archiv*, Bd. 66, S. 439.

hard rubber trough, 5 cm. × 5 cm. × 20 cm. and containing 1 cm. depth of tap water. The current, from the ordinary lighting circuit, passed through a water rheostat, pole changer, milliammeter and key, and was received at either end of the trough by

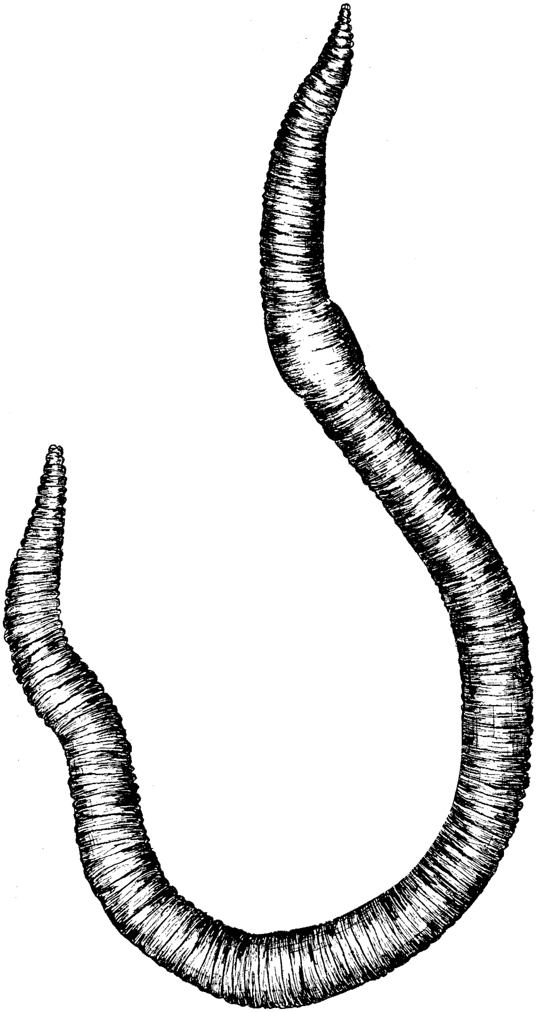

FIG. 1.

non-polarizable electrodes made of wet filter paper. The strength of current used varied between 20 and 100 milliamperes per square decimeter, voltage 110. As soon as the current was made

the worm began to orient itself and in a few seconds the anterior and posterior ends were directed toward the kathode, so that the animal took the form of a U with the concave side toward the kathode (Fig. 1). In this situation it continued to make writhing and progressive movements, and therefore the figure varied somewhat from time to time. If, by reason of excessive movements, any part of the worm showed anodal curvature, the latter was instantly corrected by contraction of the muscles on the kathodal side. Because of the anterior end of the worm being always the more vigorous in its movements, the animal ultimately succeeded, as a rule, in crawling to the kathode.

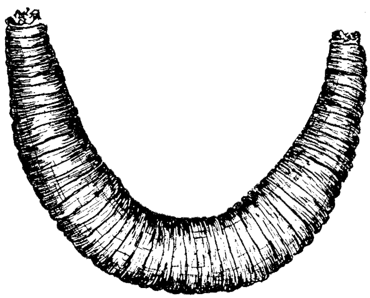

FIG. 2.

If it were cut into pieces 3 to 4 cm. long, these pieces when placed transversely in the trough and subjected to the action of the constant current, continued to orient themselves in the same fashion as an entire worm (Fig. 2) but progressive movements were absent. When the current was reversed, the specimen, either entire or sectioned, immediately responded by turning its ends towards the new kathode. The delicacy of the response was lost in fatigued animals.

Since the earthworm has but two muscle systems with which to accomplish its locomotion, viz: circular and longitudinal, it is obvious that one-sided movement or bending can be brought about only by unequal contraction of the longitudinal muscles on the two sides. It would seem that this is a case in which an entire animal responds to the electric current in the same fashion as did Bancroft's[1] medusa tentacles and bell strips. Since no

[1] Bancroft, F. W., *Journ. Exp. Zool.*, Vol. I., p 289.

locomotor limbs are involved in the earhtworm's reaction its response accords in as simple a way as possible with Loeb's theory of galvanotropism. We may therefore conclude that the constant current produces the effects described by increasing the tension of the longitudinal muscles on the kathodal side of the worm, which results in this part being more strongly contracted than the anodal region.